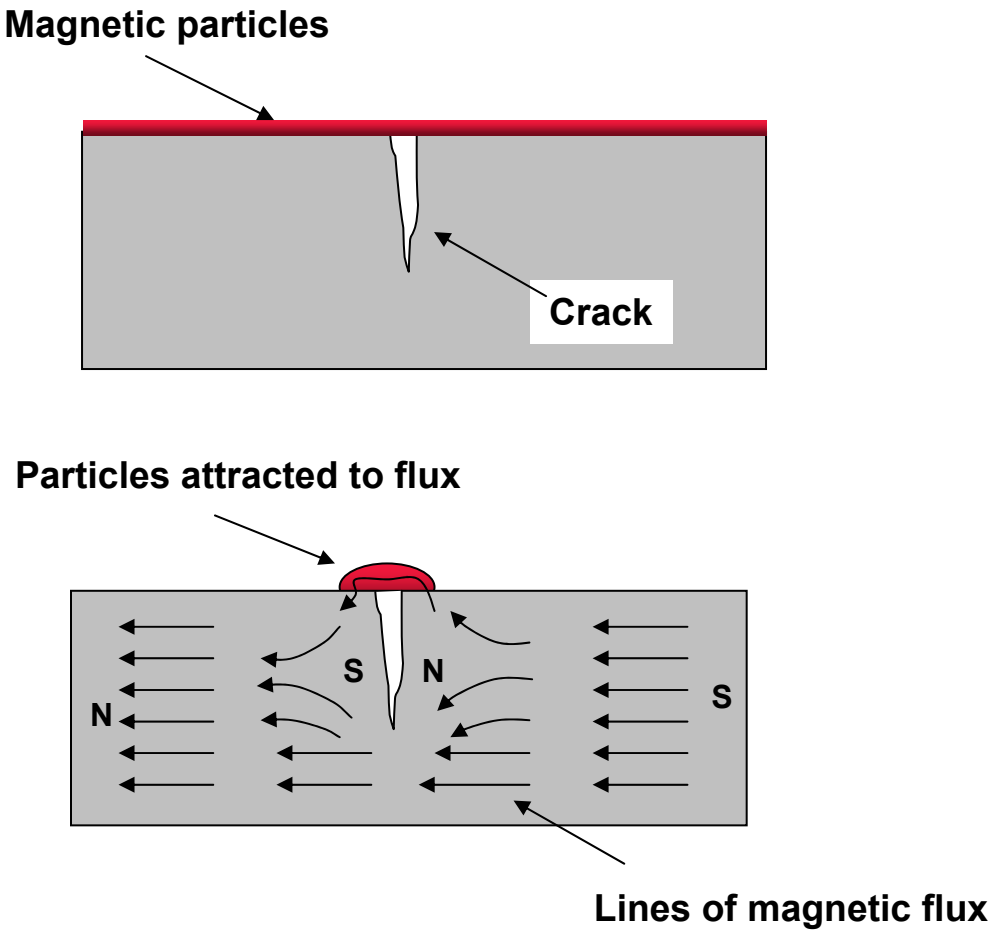

FIGURE 1. An illustration of the principle of crack detection using magnetic particles. A ferromagnetic sample, such as iron or steel, will exhibit internal lines of magnetic flux when it is magnetized. These flux lines will leak out into the air adjacent to certain features, such as at a crack. This discontinuity in properties thereby causes the area of the crack to be highlighted visually, as magnetic particles are attracted to the flux leakage.

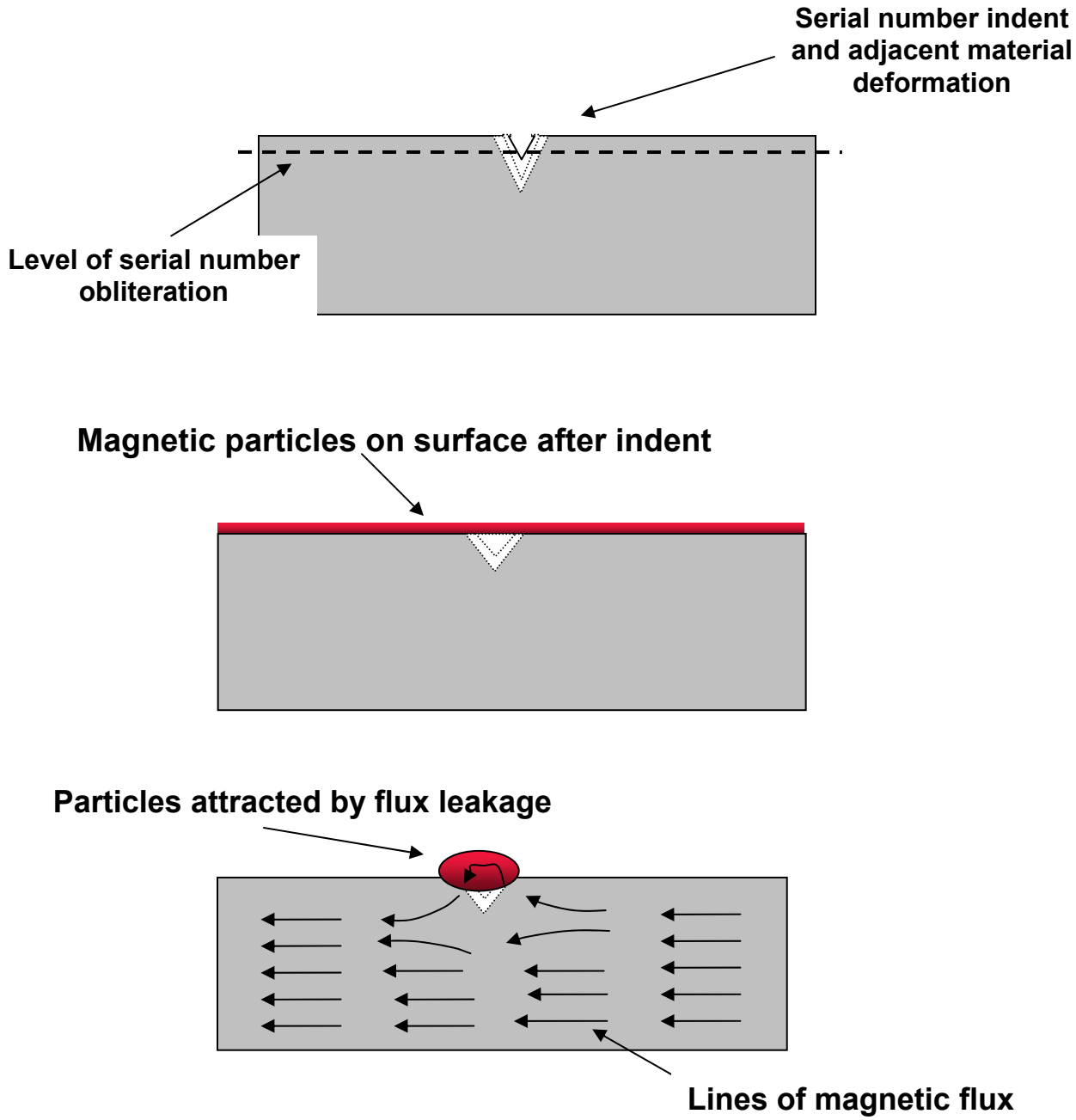

FIGURE 2. An illustration of magnetic particle testing as used in serial number recovery. In such applications, the discontinuity that causes flux leakage in a steel sample when it is magnetized is the deformed metal around a stamped indentation. Such an indication will typically be more subtle than for crack detection, and the usefulness of this approach will differ between samples with varying material properties, among other things.

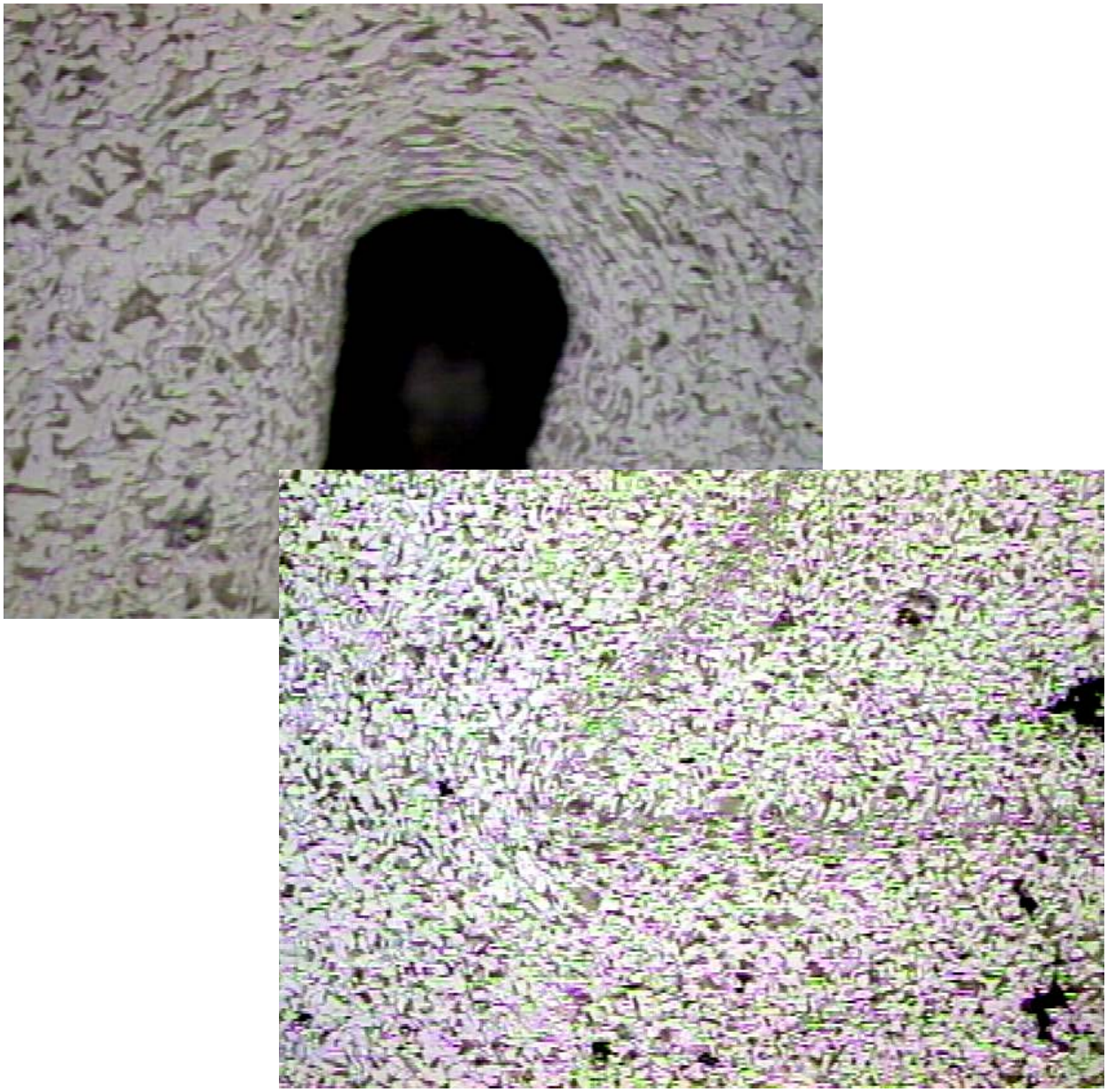

FIGURE 3. Photomicrographs of steel adjacent to a stamp indentation. Chemical etching reveals that material near the indent is deformed in directions outward from the stamp. The upper photograph shows this effect in profile near the surface of the sample, and the lower photograph shows this deformation in the structure beneath a stamped number, in this case, part of a "4" is evident. The discontinuous nature of the magnetic properties associated with this deformation is what causes magnetic particle indications to form.

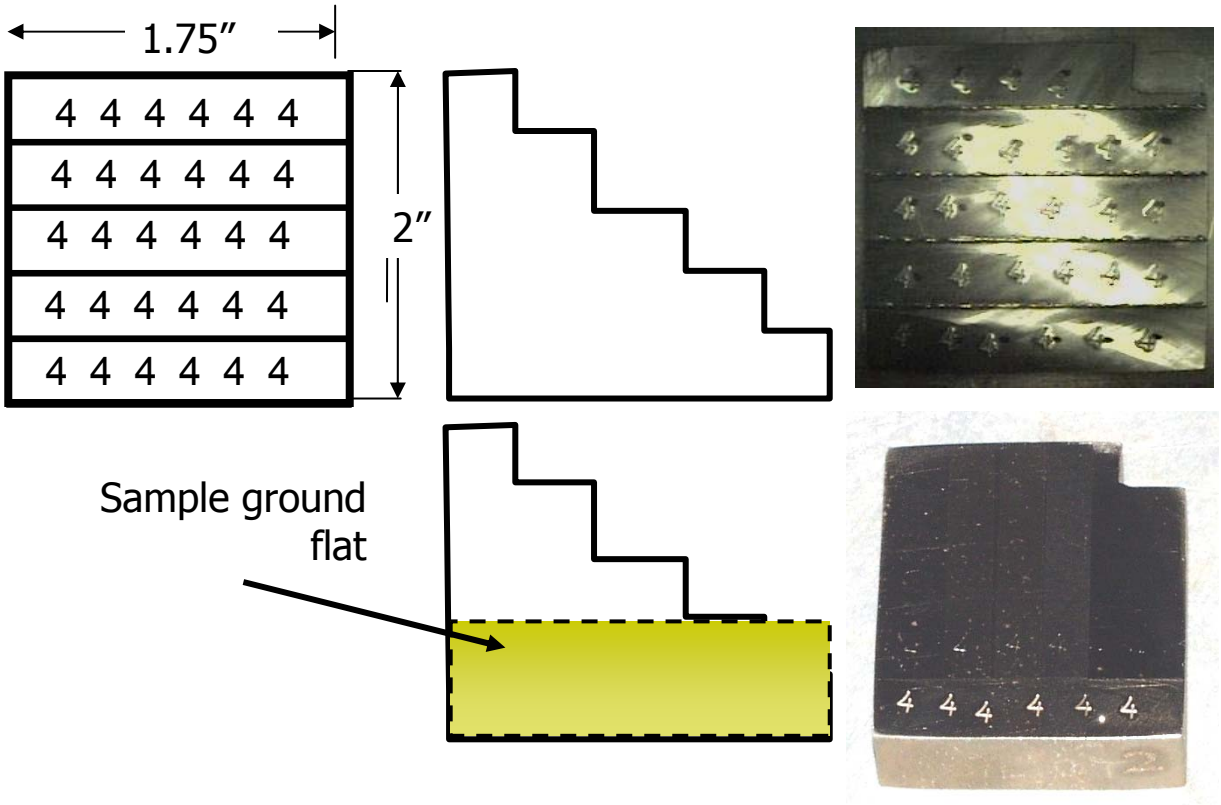

FIGURE 4. Schematic drawings and photographs of test blocks used in the serial number recovery study. The numbers were originally stamped on each step, and then the sample was ground flat, creating deformation effects of the stamps successively distant from the plane of inspection. The steps are shown exaggerated; they measured 0.005" difference in height.

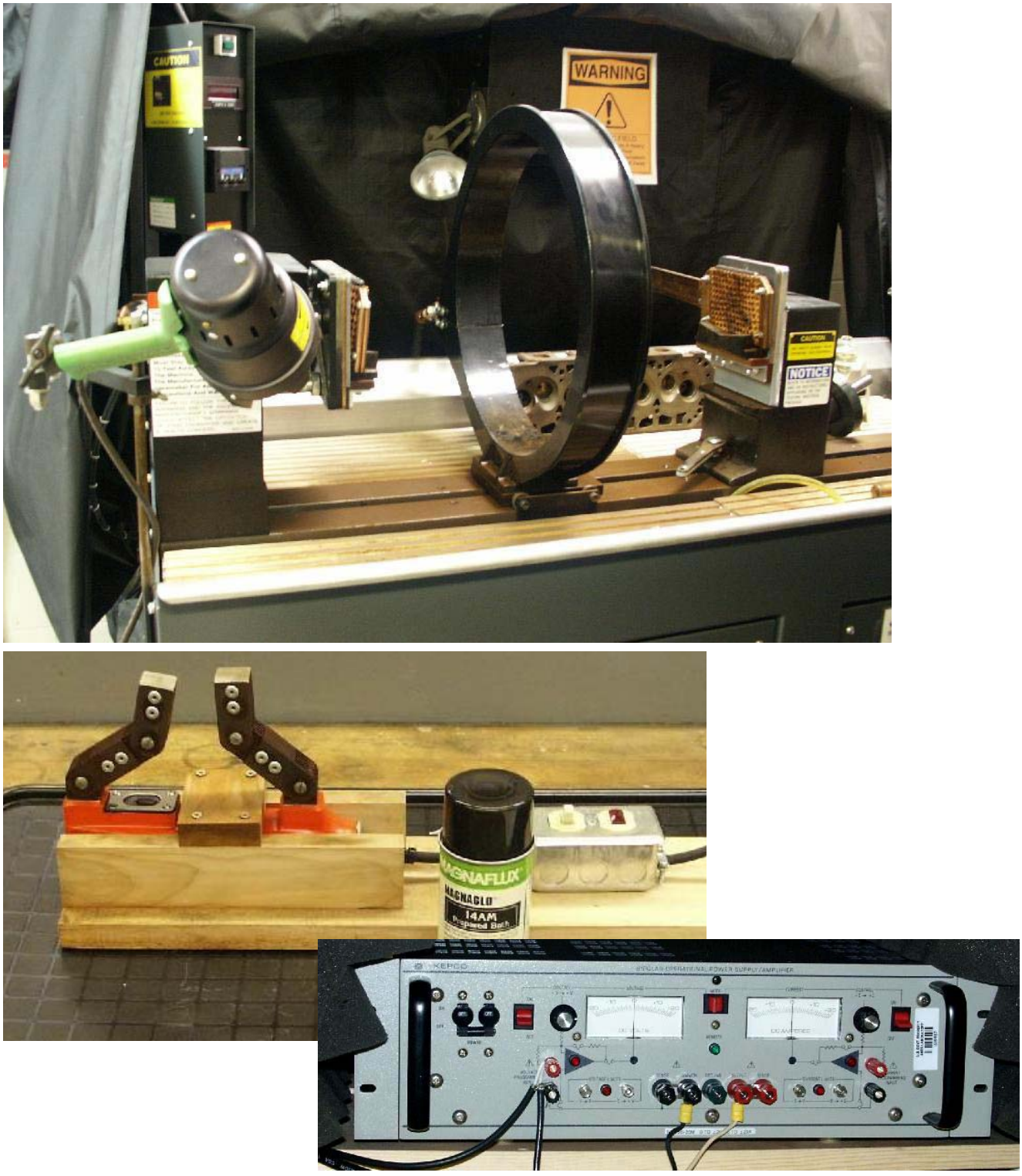

FIGURE 5. Photographs of equipment used in magnetic particle study. Top photograph shows a horizontal wet stand, including encircling coil. Lower photos show a portable magnetic yoke is a wooden holder and the power supply used to control the nature of the magnetizing current to this electromagnet.

FIGURE 6. Photographs of carbon/alloy steel and magnetic stainless steel firearms used in study. The "steel" samples are (top left) a Ruger .22 Mark II target, (top right) a Ruger .22 single-six, (middle left) a Ruger speed-six .357 magnum, (middle right) a Remington 12 gauge shotgun. The "stainless" samples are (bottom left) a Taurus .357 magnum and (bottom right) a Ruger .38 special.

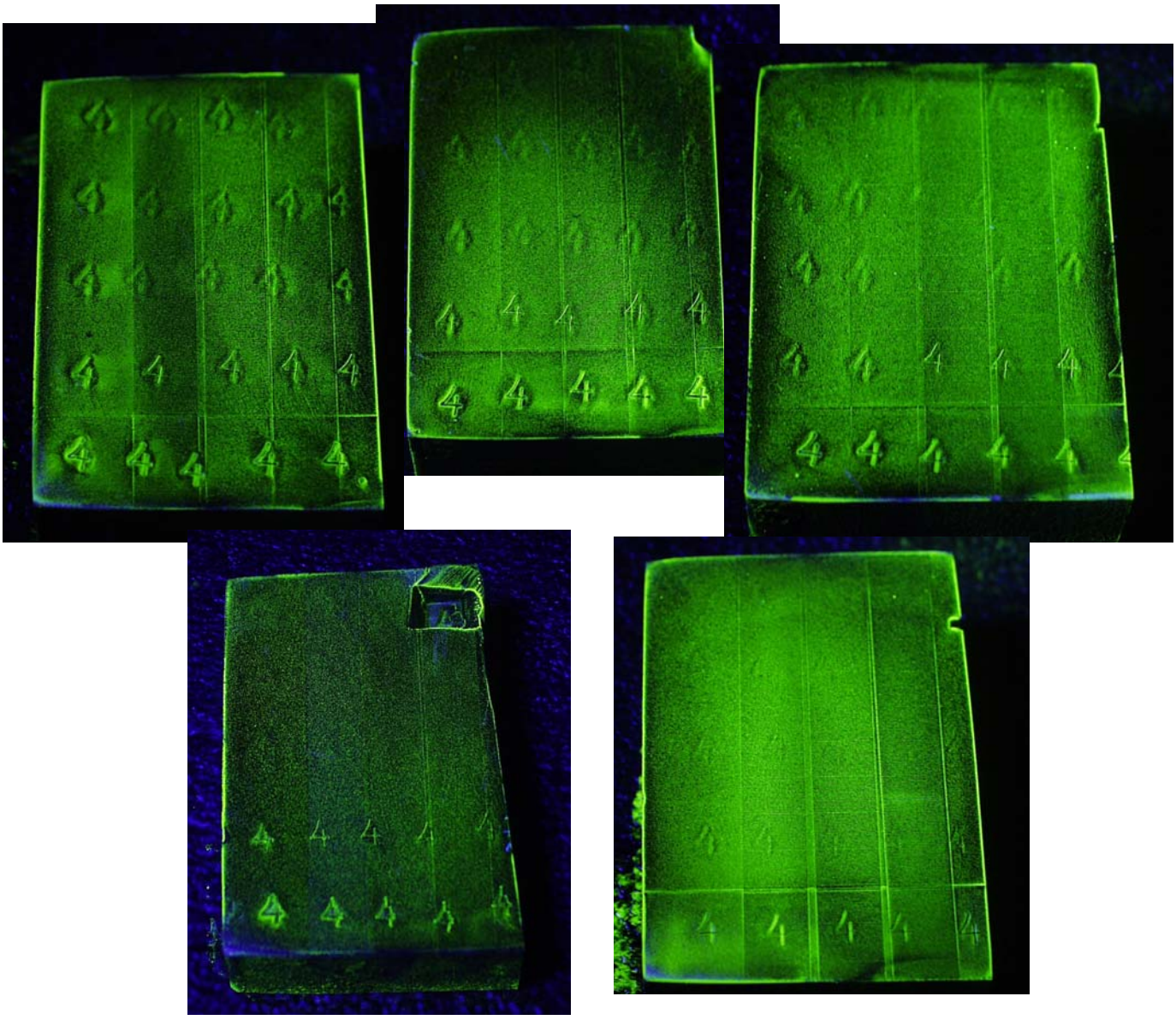

FIGURE 7. Photographs of stamped steel test blocks showing varying degrees of serial number recovery. "Best to worst" performance in magnetic particle testing were quenched and tempered samples (one shown, top left), furnace cooled (top, middle), air cooled (top, right), as received/hot rolled (bottom, left) and quenched steel (bottom, right). These test results were found to be reproducible following repeated testing, and the ranking echoed by various individuals.

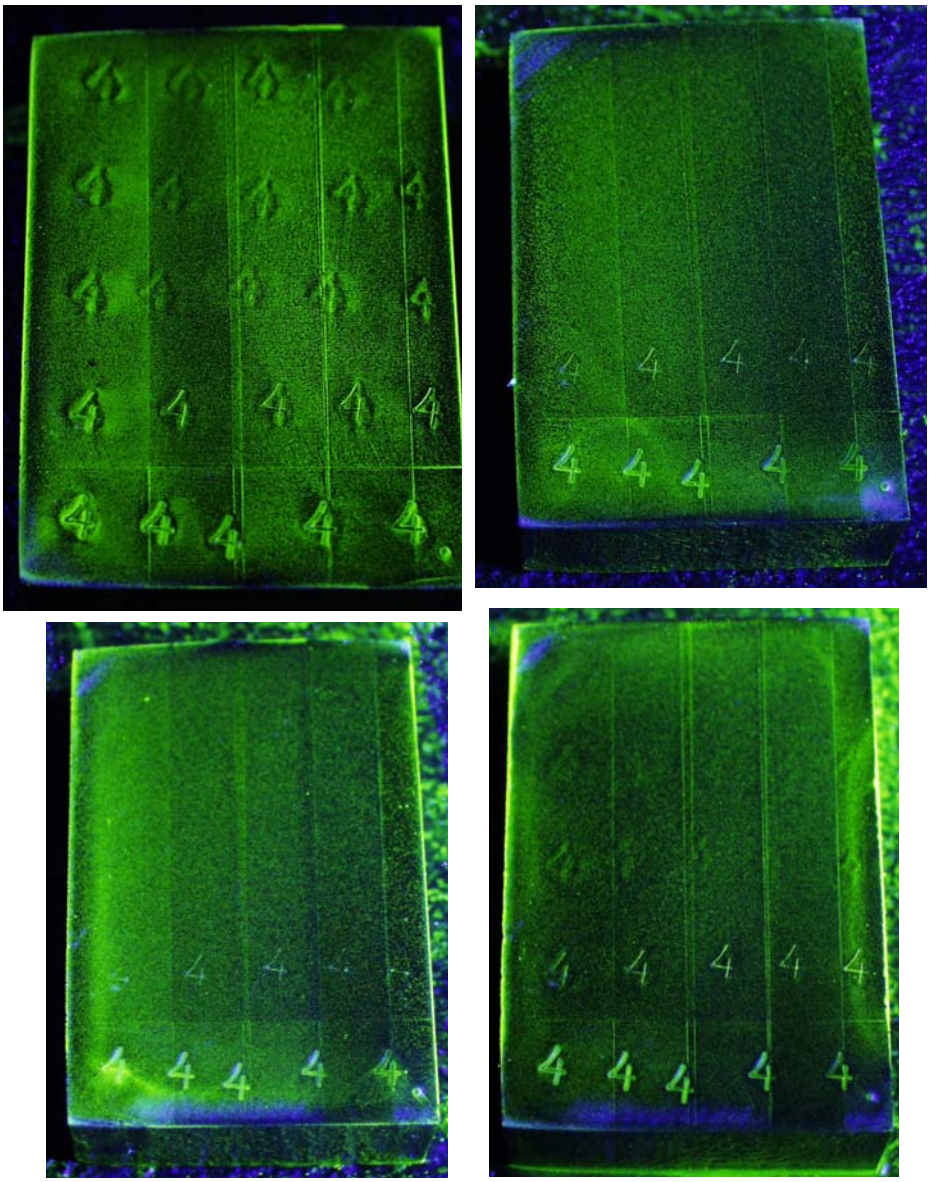

FIGURE 8. Photographs of quenched and tempered steel test block magnetized in various ways. The best results were obtained using DC excitation for the coil in a wet stand (top, left) while AC magnetization worked poorly in either the wet stand coil (top, right) or a portable coil (bottom, left). The use of a handheld yoke and DC power seemed to provide intermediate results (bottom, right), with the visibility of serial numbers significantly lower using this device compared to using a large, fixed coil.

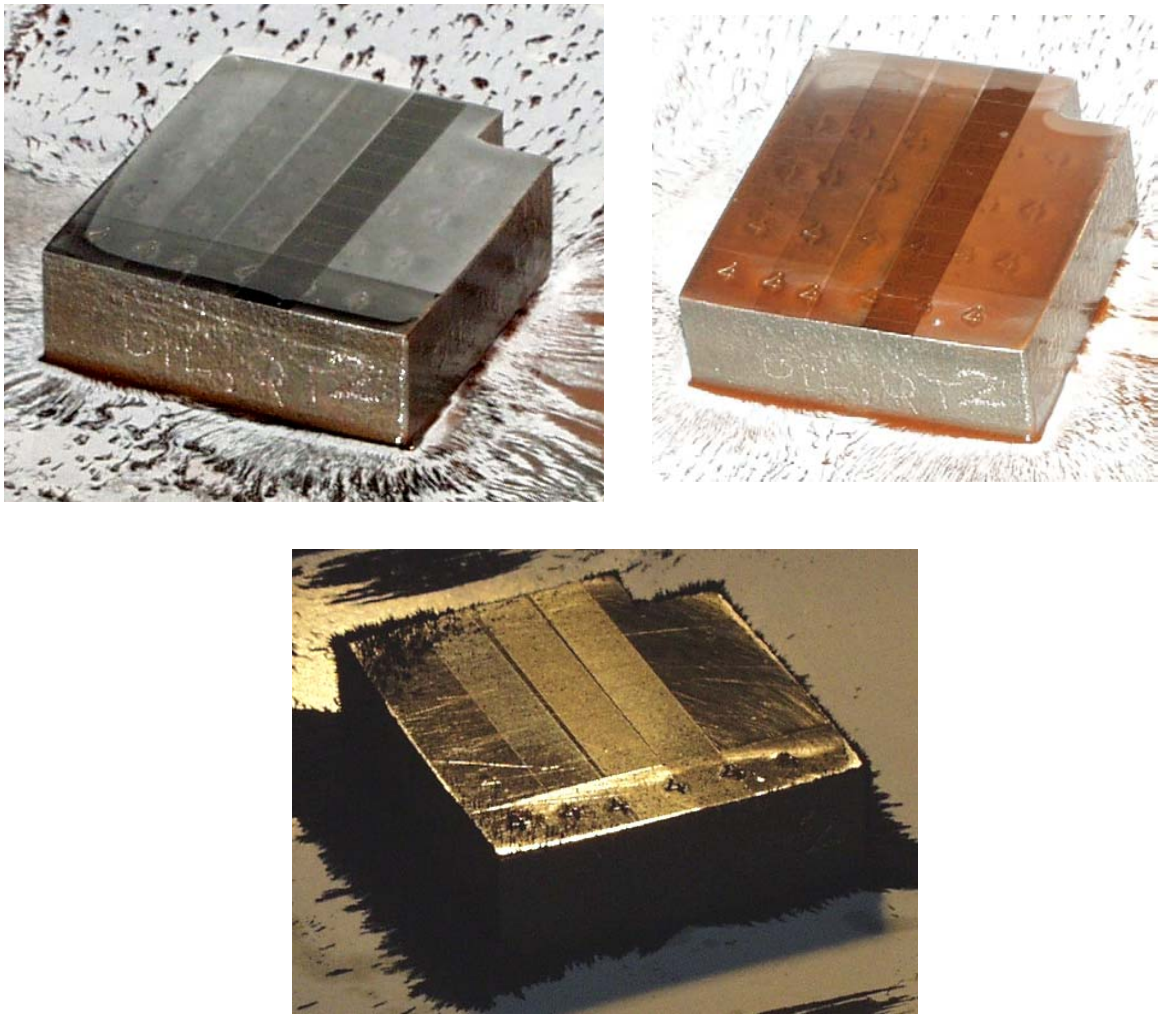

FIGURE 9. Photographs of quenched and tempered steel test block using different magnetic particles for serial number recovery. The results were obtained using DC excitation for the coil in a wet stand. The serial number recovery is shown for visible black particles in an aerosol spray (top, left), visible red particles in an aerosol spray (top right) and dry black particles (bottom left).

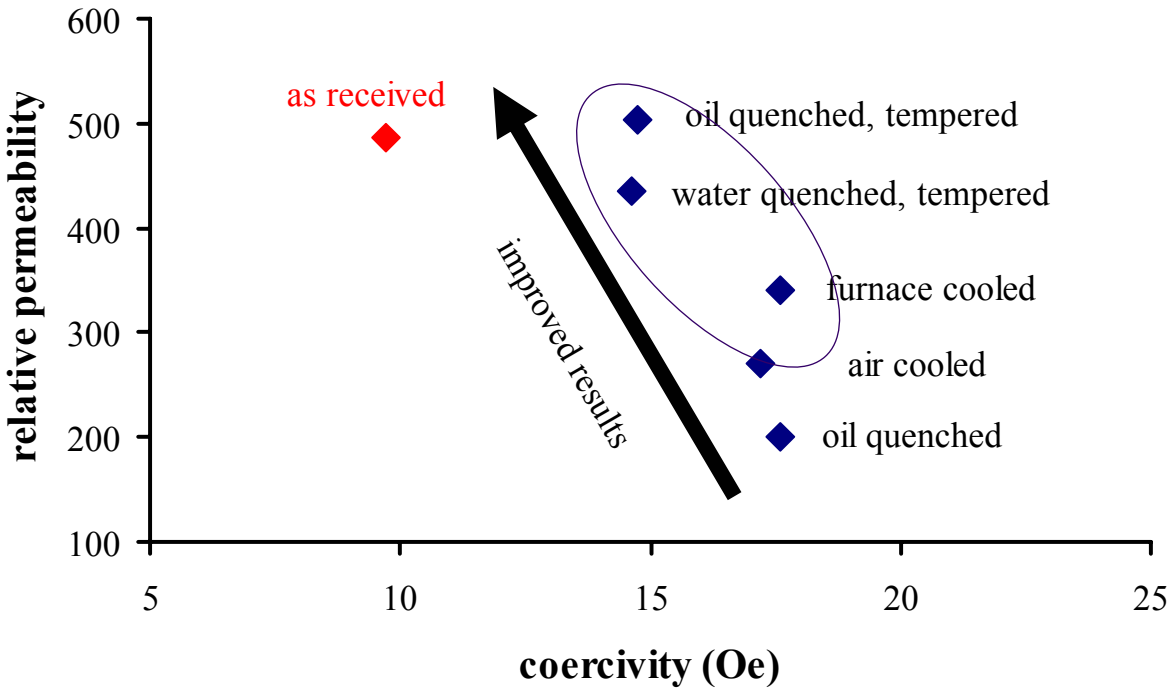

FIGURE 10. Plot of relative magnetic properties of steel samples used in the current work. The shaded oval is a theorized region indicating the combination of magnetic properties favorable to the forensic recovery of serial numbers. It remains to be seen where the properties of real firearms would lie relative to these.